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Matrix of New Concepts

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Table of Contents

Introduction	3
Dual LED/Incandescent Security Fixture.....	3
Wall Pack Fixture.....	5
LED Light Bulb	7
LED Fixture ‘Insert’	7
LED/par lamp Security Light	9
LED ‘Drop’	10
LED Pathway and Exterior Lighting	11
Concrete Mount Pathlight.....	11
LED Pathway Lighting.....	12
Conclusions	13

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Matrix of New Concepts

Introduction

New concepts for the PIER LRP Project 2.1, LED Luminaires for Exterior, Porch and Perimeter Lighting, have been developed and are summarized in this report. The concepts presented are based on the ability to meet technical requirements for specific outdoor applications, integrate LED arrays into fixture systems for optical efficiency and light delivery, and provide control and color mixing that maximizes performance while minimizing energy usage.

Using LED technology provides various benefits for outdoor applications:

- Increased security – the color change that occurs with motion activation increases user awareness that someone is in the control area.
- Back-up light with incandescent lamp failure – if the incandescent fails, the LED portion will remain on.
- Increased lighting flexibility – the LED illumination can light a door, address numbers, etc.
- Societal benefits – LED-based fixtures have the capability to reduce light trespass and light pollution.

The recommended LED concepts in this report are focused on two main outdoor applications: porch and/or security lighting, and pathway and exterior lighting. Markets for these applications include residential, commercial, and institutional. **Table 1** summarizes by market the various characteristics of using LED technology for outdoor lighting.

Table 1: LED Characteristics by Market

	Residential	Commercial	Institutional
Control	Motion/daylight	Daylight	Daylight
Color	Any	White, yellow	White, yellow
Illumination	Low (<100 lumens)	High (>1000 lumens)	Medium/High (100-1000 lumens)
Cost	Low	High	Medium/High
Energy savings	200 kW hr/year/ fixture	Unknown	Unknown
Maintenance benefit	Low	High	High
Payback	3-5 years	Unknown	Unknown

Dual LED/Incandescent Security Fixture

This main fixture concept for porch and/or security lighting is a hybrid approach to LED illumination. It combines an ‘always on’ ambient LED illuminator with a standard incandescent lamp on a motion control sensor. The LED portion will activate with the onset of darkness (daylight control) and remain on during the course of the night. The LED illumination is sufficient to provide coverage to the wall and ground area adjacent to and under the fixture. The incandescent lamp is integrated with a motion control circuit and sensor. When movement in the field of view is detected, the incandescent is switched on, providing an increased level of illumination to the area. **Figure 1** shows an example of a dual LED/incandescent security fixture.



Figure 1: Dual LED/incandescent Fixture Prototype

This type of hybrid approach to LED illumination for porch/security lighting has the following advantages/benefits:

- The LED source (one or more LEDs in an array) consumes a relatively small amount of power compared to the incandescent source, yielding substantial energy savings without a loss in functionality.
- The LED source provides ambient illumination to the area, eliminating the ‘all-or-nothing’ effect of traditional motion sensor fixtures.
- The LED source will have a very long lifetime, ensuring at least some illumination to the control area when the incandescent lamp fails.
- With colored LED sources, the motion activated incandescent will provide a color change when triggered, increasing the conspicuity of the motion activation and increasing the security benefit of the trigger.

- With colored LED sources, different nighttime aesthetics can be achieved.
- The combination of the LED source(s) and the incandescent source yields the best dollars per lumen ratio for the target applications. The number of (expensive) LEDs is kept to a minimum while, at the same time, the incandescent provides a high lumen output for good visibility when the application area is occupied.
- The LED fixture can use interchangeable LEDs. LBNL will be able to test various colors.
- With continued advances in LED technology, the lumens per watt will improve requiring less fewer LEDs per fixture, which will lower the cost of the resulting product.
- The wattage could be reduced from 60 watts (typical incandescent wattage) down to approximately two watts when no activity is detected. The average wattage would be six or seven watts per fixture per night. **Table 2**, shown below, details the lamp life, energy usage, and savings with hybrid fixtures using LED technology as compared to standard incandescent and CFL only technology.

Table 2: LED/Incandescent/CFL Comparisons

	Standard		PIER Improved	
	Incand. Only	CFL Only	LED+Incand.	LED+CFL
Full Power (W)	60	20	64	24
Reduced (W)	0	0	4	4
Hours/year Full	3650	3650	365	365
Hours/year Reduced	0	0	3650	3650
KW/Year	219	73	37.96	23.36
Main Bulb Lifespan (Hrs)	1,000	10,000	1,000	10,000
Main Bulb Lifespan (Yrs)	0.27	2.74	2.74	5.00
Cost/Year (Bulb)	\$0.91	\$5.11	\$0.09	\$2.80
Cost/Year (Electricity)	\$32.85	\$10.95	\$5.69	\$3.50
Total Cost/Year	\$33.76	\$16.06	\$5.79	\$6.30
Savings vs. Incand (1 year)	N/A	\$17.71	\$27.98	\$27.46
Savings vs. CFL (1 year)	N/A	N/A	\$10.27	\$9.75
Savings vs. Incand (5 years)	N/A	\$88.53	\$139.89	\$137.30
Savings vs. CFL (5 years)	N/A	N/A	\$51.36	\$48.77

Wall Pack Fixture

There are several different embodiments of the basic hybrid concept. The first embodiment (**Figure 2**) combines the LED and incandescent lamps into a single fixture. The incandescent source is held in a horizontal position, and the LED array is placed facing down. The construction of the fixture is such that the light output is directed down, mitigating light pollution issues. This fixture is intended as a replacement fixture: it either replaces a porch light in a retrofit application, or is used in new construction as an alternative to another porch light.

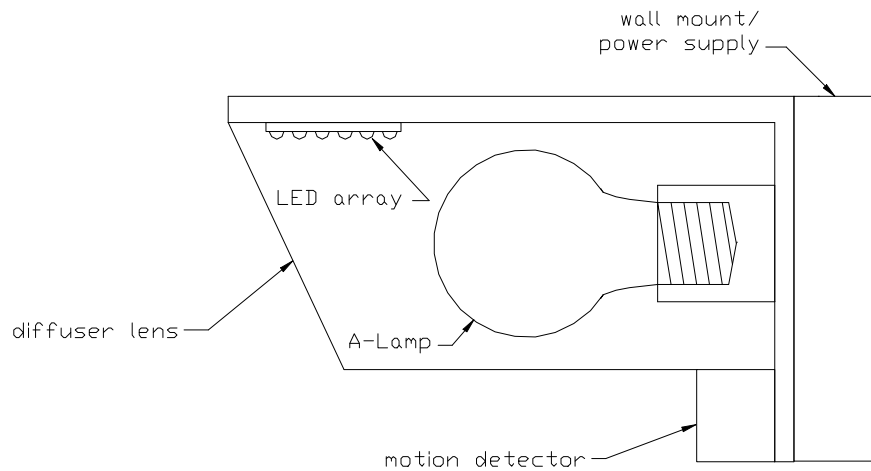


Figure 2: Combination LED/Incandescent Horizontal Fixture

The next embodiment is similar to the first. However in this concept, the incandescent is in a lamp down orientation (**Figure 3**). The LEDs are wall-mounted in a ring around the base of the lamp.

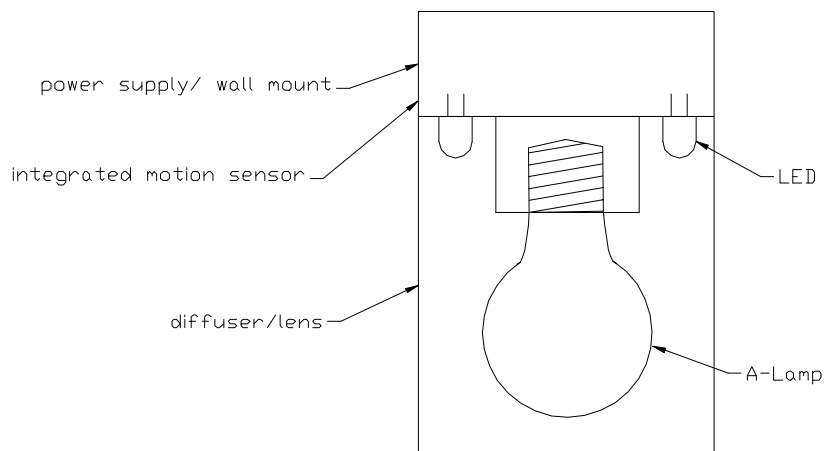


Figure 3: Combination LED/Incandescent Vertical Fixture

LED Light Bulb

The next version (**Figure 4**) is intended as a screw-in retrofit. The LEDs and electronics are integrated into a screw-in A-lamp type base. This base then receives a standard lamp. A light guide that attaches to the base may be necessary to control the light distribution, as well as mitigate direct glare from the LEDs.

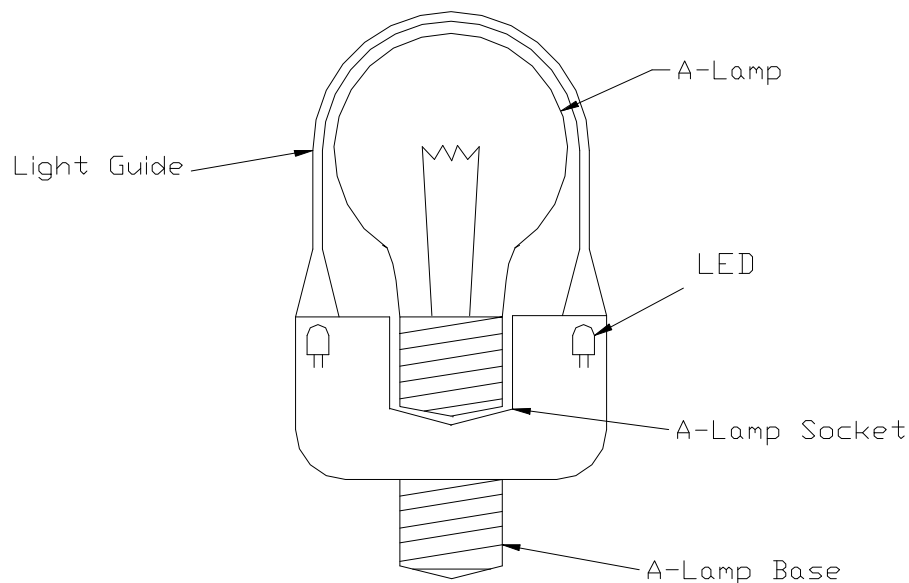


Figure 4: Screw-in A-lamp type base

LED Fixture 'Insert'

To address the issue of aesthetics, LBNL has developed an innovative concept (**Figure 5**) that separates the LED lighting component from the incandescent porch light fixture. This unit attaches to an outdoor junction box and is built to receive a porch light fixture on the front surface.

This concept provides the consumer with the flexibility to use the existing incandescent fixture. The LED component box would be designed to accept most incandescent porch light fixtures. A three dimensional model of this concept is shown in **Figure 6**.

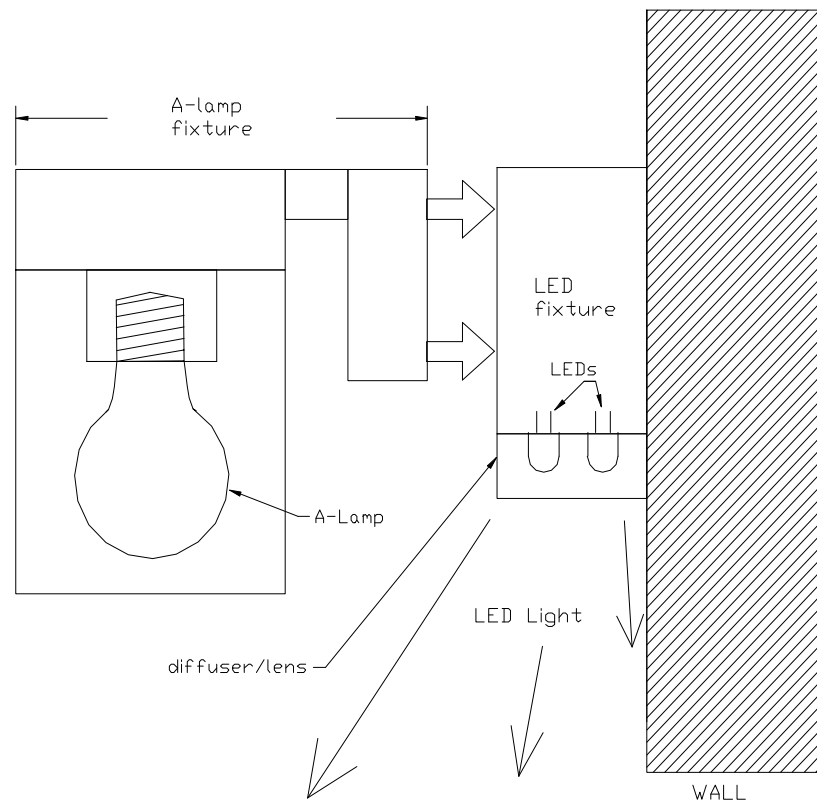


Figure 5: LED Fixture ‘Insert’

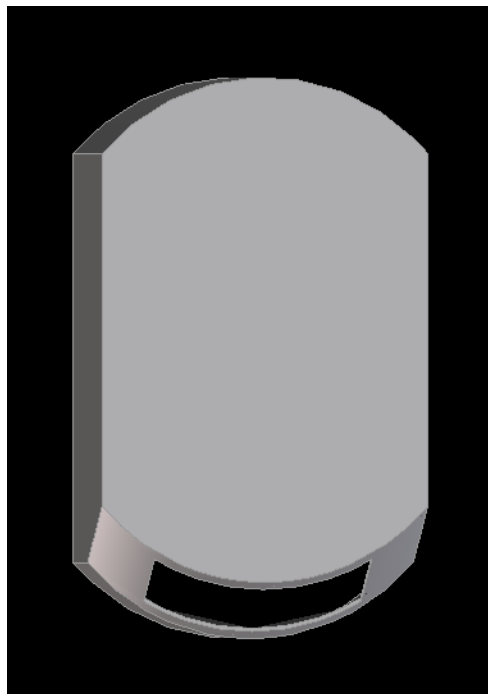


Figure 6: Three-dimensional Model of Wall Unit

LED/par lamp Security Light

The next concept employs the same hybrid approach in a par lamp type security fixture (**Figure 7**). These fixtures are commonly equipped with a motion sensor that attaches to the middle of the fixture. Integrated into this motion sensor assembly will be an LED illumination unit. The unit may be the entire plate assembly, or could just include the motion sensor/LED light unit that screws in to a standard security light receptacle. These fixtures are commonly available and accept standard ½” fittings.

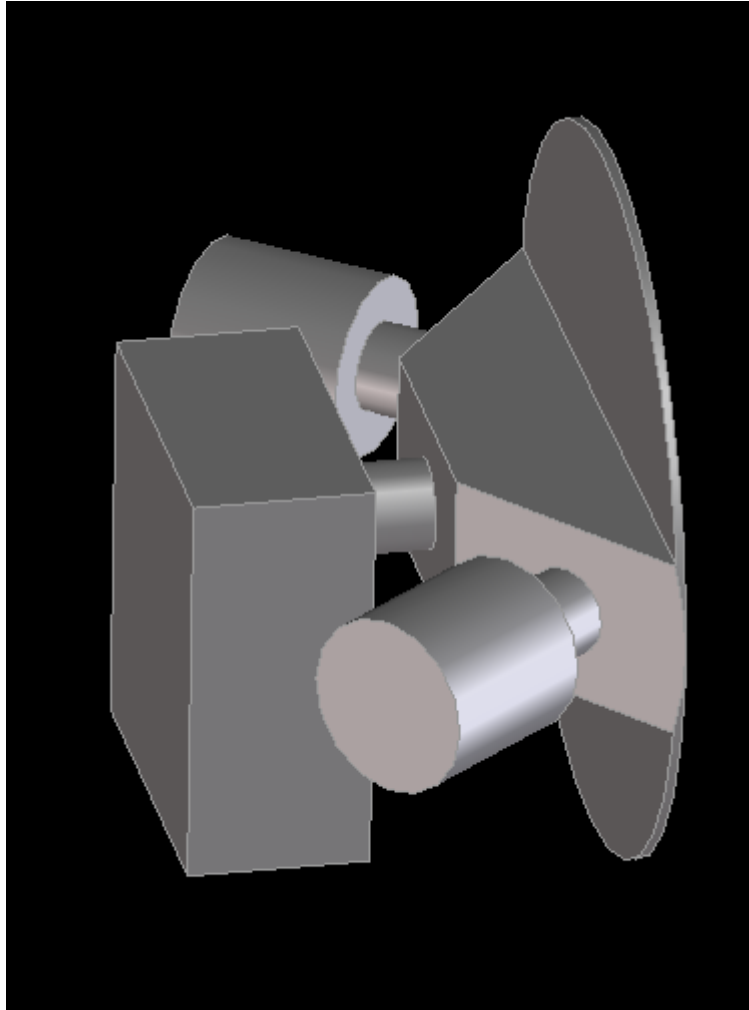


Figure 7: PAR Hybrid Fixture

LED ‘Drop’

The last embodiment of this design also separates the LED light component from the incandescent fixture. Instead of having the LED, motion sensor, and control electronics in the same box, this design employs an LED ‘drop’ unit under the main unit (**Figure 8**).

This drop would have an adjustable length, and could be set by the end user according to the particular installation environment. This ‘drop’ feature accomplishes several things.

- It lowers the LED emitters, reducing the problem of direct glare from the LEDs and increasing the illuminance on the ground below the fixture.
- It allows the motion sensor unit, also incorporated into the ‘drop’, to clear the porch light fixture and see the appropriate field of view for proper motion sensing operation.
- It also separates the heat generating LEDs from the rest of the unit, keeping the heat away from the control electronics.

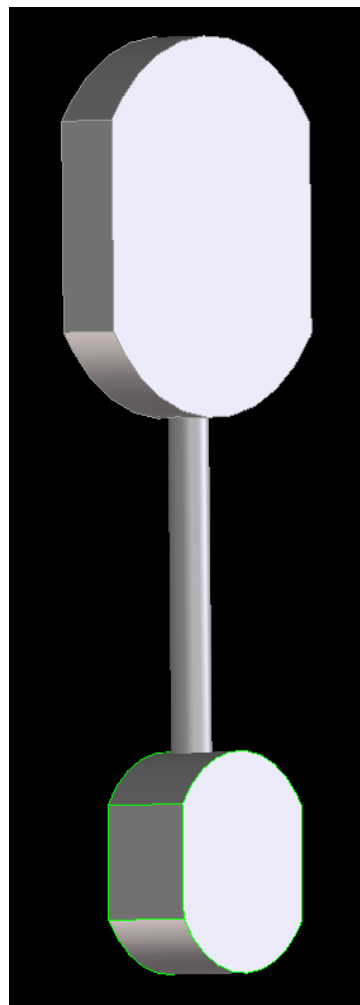


Figure 8: LED ‘Drop’ Unit

LED Pathway and Exterior Lighting

The second major application that LBNL has been investigating for the use of LED technology is pathway and exterior lighting applications.

Concrete Mount Pathlight

One concept integrates a five-watt (or higher) white LED into a concrete mounted ‘insert’ unit. The size of the case is similar to the size of a standard residential electrical outlet. The case mounts into a receptacle that is cast in place in new concrete construction, or onto a mounting plate attached to the surface of a concrete wall or building. The fixture uses the concrete as a heat sink. Although concrete is a poor heat conductor, the large physical size of a concrete structure provides a very large thermal mass.

This fixture (**Figure 9**) is intended for low mounting height exterior applications. It can serve as pathway lighting, building exterior lighting, or concrete planter curb lights.

The three primary design considerations for this concept are the LED electrical driver, the LED optics, and the thermal management. The LED optics portion is likely to be the key factor in separating the LBNL design from other competitors. Initial laboratory tests have shown some promise in this area.

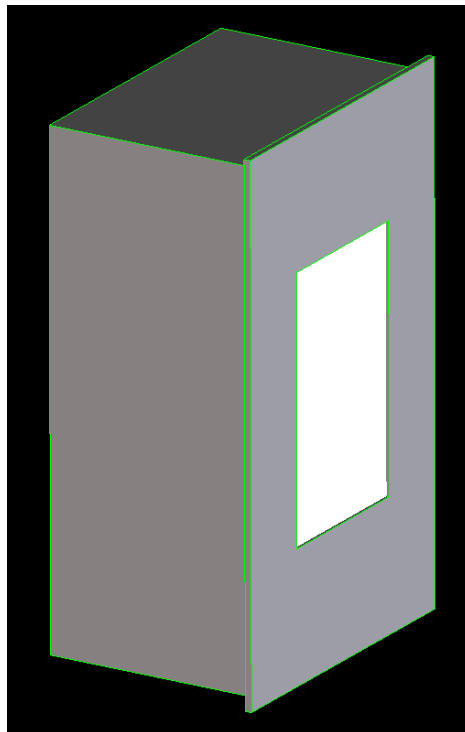


Figure 9: LED Concrete-mounted ‘Insert’ Unit

LED Pathway Lighting

This concept utilizes low mount LEDs to light a pathway or similar environment. The current market for this type of lighting, as considered for this research, can be divided into two general areas: low voltage incandescent line powered lighting, and stand-alone LED solar powered lights. Commercial and institutional sites often employ incandescent ‘bollard’ or ‘malibu’ style path lights, while the residential market has seen some penetration of low cost solar-powered LED style lights.

Investigation into the photometric properties of these two classifications of fixtures has revealed the following:

- Incandescent path lights provide adequate illumination to the task plane.
- Incandescent path lights have very low fixture efficiencies (less than 10 percent).
- Solar path lights provide inadequate illumination to the task plane.
- Solar path lights utilize low output T-1 ¾ LEDs.

There appears to be an opportunity to use high output LEDs for this application. Pathway lighting fixtures can be designed that provide the illuminance of halogen-based systems with the energy and longevity benefits of LED technology.

Several different manifestations of this system have been conceived. The first and most basic type is a drop-in replacement for halogen-based systems. The bollards or pathlights would be configured to receive low voltage inputs common in landscape lighting. (**Figure 10**).

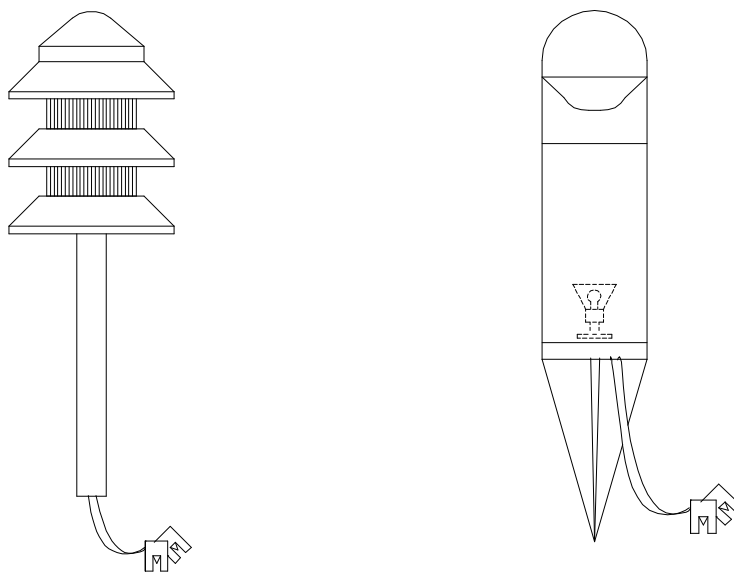


Figure 10: ‘Malibu’ and ‘bollard’ style pathlights

Another manifestation would be a systems-oriented approach. The fixtures would be designed as components in a system, with a central power unit and appropriate controls. This system could be powered by a line connected transformer unit, or a central solar powered unit and battery pack (**Figure 11**). Motion sensor controls would be incorporated to lower energy consumption and increase user features.

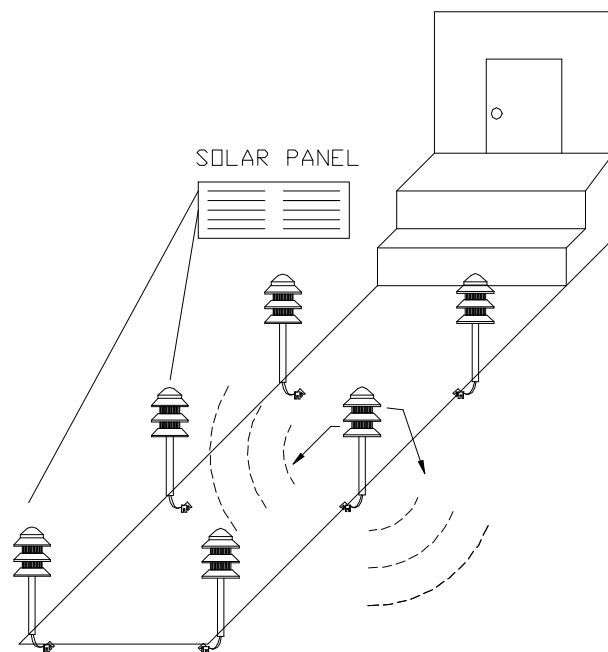


Figure 11: Systems-oriented LED Landscape Lights

Common to all approaches will be the proper design of the LED optics to provide high fixture efficiencies and high ‘delivered lumens’ to the target task plane. This approach will include the investigation of novel optical designs that have shown promise in initial laboratory tests.

Conclusions

Based on the concepts presented in this report, LBNL will begin to develop prototypes of the designs. Aesthetics of the new fixtures, cost of the resulting products, and energy savings will be important considerations during the next phase of the project. Additionally, two potential manufacturing partners and one municipal utility have been contacted. All have shown substantial interest in participating in this project.